

## PATENT SPECIFICATION



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382,974

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Complete Accepted: Nov. 10, 1932.

## COMPLETE SPECIFICATION.

## Improvements in or relating to Colour Photography.

We, KODAK LIMITED, a Company registered under the Laws of Great Britain, of Kodak House, Kingsway, London, W.C.2, (Assignees of MERRILL  
 5 WILMER SEYMOUR, Citizen of the United States of America, of Kodak Park, Rochester, New York, United States of America), do hereby declare the nature of this invention and in what manner the  
 10 same is to be performed, to be particularly described and ascertained in and by the following statement:—

This invention relates to colour photography and has more particular reference  
 15 to a method of and apparatus for printing from one support or film to another.

In photographic colour processes according to which a support having microscopic lens elements is exposed or projected by  
 20 means of an optical system comprising an objective and a polychromatic screen or filter it is desirable that the filter, when viewed from any individual minute lens element shall subtend the same angle,  
 25 that is shall appear the same both in taking and projecting. It is often desirable however to employ objectives of different focal lengths for making the exposure and for projecting the exposed  
 30 film, and with a view to providing for the use of the same photographic support in such a case for exposure and projection, it has been proposed in our British patent No. 318,040 to provide optical systems for  
 35 cameras and projectors wherein the centre of curvature of the gate or guide for the support in each system lies on the optical axis of the objective and the curvatures of the gates are such that the angle  
 40 between a line drawn from a given point on a gate to the centre of curvature and a line from the same point to the intersection of the optical axis and the virtual image of the filter is the same for each  
 45 gate. The photographic record made in a camera is thus suitable for projection only by a projector having certain characteristics which correspond to corresponding characteristics of the camera. Since  
 50 however projectors having widely differing characteristics are in use it is desirable to be able to produce not only prints which are suitable for use with projectors having

characteristics corresponding to those of the camera but also prints which can be  
 55 employed with projectors whose characteristics differ from those of the camera. The present invention enables this to be effected by the use of a simple form of apparatus wherein the same optical system  
 60 may be utilised whatever the characteristics of the projector for which the print is intended.

According to the present invention a record or copy having colour values is  
 65 printed from an original record formed through a colour filter, one or each of these records being made on a lenticulated or similarly embossed support, by interposing between the supports an optical  
 70 system having a focal length independent of that of the objective of the camera in which the original support was exposed and of that of the objective of the projector by which the printed record is to  
 75 be shown, so that a composite "aerial image" of the colour filter is formed within the optical system and is projected on to the support to be printed, and  
 80 guiding the supports by gates or the like at least one of which is curved, the curvatures of the guides being such that the angle between a line drawn from a given point on a support to the centre of curvature of the gate guiding that support and  
 85 a line from the said point on the support to the point of intersection of the optical axis by the virtual image of the filter is, in the case of the original support, equal to the corresponding angle in the camera  
 90 and, in the case of the support to be printed, equal to the corresponding angle in the projector.

The phrase "aerial image of the filter" is to be understood for the purpose of  
 95 this specification to mean an artificially produced image representation of the filter through which the original record was taken in the camera, such representation  
 100 having colour areas corresponding to the colour areas of the filter.

Various arrangements of printing apparatus according to the present invention are illustrated somewhat diagrammatically and by way of example in the accom-  
 105 panying drawings, in which

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Figures 1 and 2 illustrate an arrangement suitable for printing from one lenticular support to another.

Figures 3, 4 and 5 show three further arrangements with modified forms of guides or gates.

Figures 6 and 2 illustrate apparatus for printing from a plain support to a lenticulated support and vice versa respectively, and

Figures 6 and 7 illustrate apparatus for unit shown in Figures 6 and 7, but on an enlarged scale.

In the arrangement illustrated in Figures 1 and 2 the apparatus comprises a curved gate 6 through which the original lenticular film 7 bearing a photographic record representing pictures having colour values is moved from a supply reel 8 to a take-up reel 9 by means of feed mechanism indicated at 10. Arranged behind the window 11 of the gate 6 is a light source 12 with a suitable reflector 13 whereby that portion of the film 7 within the gate 11 is uniformly illuminated. Similarly, the lenticular support 14 upon which the record is to be printed is moved from a supply reel 15 through a curved gate 16 on to a take-up reel 17 by means of feed mechanism indicated at 18. The feed mechanisms 10 and 18 are interconnected so that the films 7 and 14 are moved synchronously a frame at a time through their respective gates.

The gate 16 is furnished with a window 19 arranged opposite to the window 11 and an optical system 20 is positioned between these two windows, this system serving to project on the photographic surface of the film 14 the photographic images as these were projected on the film 7 when this film was originally exposed in the camera.

In the construction illustrated the lens elements on the films are assumed to extend transversely to the length of the film in each case and the gates 6 and 16 are each curved about an axis parallel to the longitudinal axes of these lens elements. The lens system 20, as clearly shown in Figure 2, comprises two lens units 21, 22 and these units are so arranged that when the light source 12 is illuminated the lens unit 21 forms an image of the picture on the original film 7 substantially at infinity, the microscopic images of the camera filters on the emulsion surface 32 being focussed by the lens elements of the film 7 so as to form within the lens system 20 a composite aerial image 23. Thus, assuming that the camera filter included bands or strips coloured respectively red, green and blue the aerial image 23 will consist of corre-

sponding component pictures indicated at R, G and B. The lens unit 22 then focusses the parallel rays from the various points on the original film so as to form an image of the original picture within the window 19, the lenticular or lens elements on the film 14 serving to re-image the aerial image 23 on the emulsion surface 33 of the film 14.

It is frequently desirable in printing a film taken in a camera having a lens of one focal length and of one curvature to utilise printing apparatus wherein the corresponding lens unit may have a different focal length, and similarly to use in the printing apparatus a lens unit the focal length of which may differ from that of the objective of the projector which is to be employed for showing the printed film. In order to obtain the conditions described above in respect of the apparent direction of the filter images from the lens elements without making the focal length of the lens unit 21 equal to that of the taking camera the curvature of the gate 6 may be different from that of the camera gate, the arrangement being such that the angle  $\alpha$  between a line drawn from the centre of curvature 24 of the gate 6 to the optical centre indicated at 26 of any lens element and another line drawn from this optical centre to the point 35 at which the virtual image  $V^1$  of the aerial image of the filter with respect to the left hand half of the printer intersects the optical axis 28, 29 of the system, is equal to the correspondingly defined angle in the taking camera. Similarly the curvature of the gate 16, which curvature may differ from that of the projector gate, is so selected that the angle  $\beta$  between a line drawn through the centre of curvature of the gate 16 (which in the example illustrated happens to coincide with the centre of curvature 24 of the gate 6) and the optical centre 31 of any lens element on the film 14, and another line drawn through this optical centre to a point 34 at which the virtual image  $V^2$  of the aerial image of the filter with respect to the right hand half of the printer intersects the optical axis 28, 29 is equal to the similarly defined angle in the projector by which the film 14 is to be shown.

The arrangement of the apparatus shown in Figure 3 only differs from that above described in that the gates 6 and 16 are convex with respect to the optical system instead of concave as above described. The centre of curvature of each gate is thus disposed on that side of the gate remote from the lens unit associated therewith, the angle  $\alpha$  between a line joining the centre of curvature of

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the gate 6 to the optical curve of any lens element on the film 7 and a line joining this optical centre to the intersection of the virtual image  $V^1$  with the optical axis 28, 29 is equal to the correspondingly defined angle in the camera in which the film 7 was exposed. Similarly the angle  $b$  is equal to the correspondingly defined angle in the projector by which the printed film 14 is to be shown.

In Figure 4 the gate 16 for supporting the recording film 14 is substantially flat and may therefore be regarded as having its centre of curvature at infinity, the angles  $a$  and  $b$  being respectively equal to correspondingly defined angles in the camera and projector as above described. In Figure 5 the gate 6 for the original film is substantially flat with its centre of curvature at infinity.

It will be appreciated that while either the camera lens or the projector lens may have the greater focal length it is usual for the projector lens to have the greater focal length and this has above been assumed to be the case. As a result the image corresponding to the camera filters will usually be focussed at a shorter distance from the film than the image of the projection filters. Further it is also desirable that the lens unit 21 have a greater focal length than the camera lens so that the aerial image of the filters in the printing apparatus will be formed at a greater distance from the original film than was the case while the film was being exposed in the camera.

Figure 6 illustrates an arrangement for printing from a three-colour separation picture recorded, for example, as described in our copending British Patent Application No. 23,104 of 1931 on unembossed panchromatic film 40 and supported in a flat gate 41, to a lenticular film 43 supported by a curved gate 44. A lens unit 45 is provided between the gates 41, 44 the arrangement being such that the gates and lens system bear a predetermined relationship to the gates and lens systems of the camera and projector respectively as above described. Figure 7 illustrates the converse arrangement in which a picture taken on a lenticular film 50 and supported by a curved gate 51 is printed by means of the lens unit 45 as a three-colour separation picture on unembossed film 53 supported by a flat gate 54.

The lens unit 45 has three lenses 55, 56 and 57 which are so arranged that when the unit is in position as shown in Figure 6 or Figure 7 the longitudinal axes of the lenses 55, 56 and 57 meet the lenticular film 43 or 50 at points thereon spaced apart in a direction at right angles to the length of each lenticulation.

From the above it will be seen that whilst at least one of the gates is curved the radius of curvature of either of the gates may vary from a finite positive or negative value to an infinite value in which the gate assumes a flat surface, the gate being flat, convex or concave. Thus, if a flat gate is provided for the original support a concave or convex gate may be employed for the support to be printed or a convex or concave gate may be used for the original support with a flat, convex or concave gate for the support to be printed.

In each of these cases, however, the axis of curvature of the gate is parallel to the colour bands of the original filters employed when exposing the film, the longitudinal axes of the lens elements on the supports being parallel to the bands of these colour filters. It will be understood, however, that instead of the films being embossed with cylindrical lens elements these may be spherical provided that the gate is curved about an axis parallel to the length of the colour bands of the filters. Further, while the lens system has been illustrated as substantially equi-distant from the two gates the position of the lens system may be varied in accordance with the size of the desired print, i.e. whether it is to be of the same dimensions as the original or is to appear as a reduction or enlargement thereof.

Having now particularly described and ascertained the nature of our said invention and in what manner the same is to be performed, we declare that what we claim is:—

1. In colour photography the method of printing a record or copy having colour values from an original record formed through a colour filter, one or each of these records being made on a lenticulated or similarly embossed support, which consists in interposing between the supports an optical system having a focal length independent of that of the objective of the camera in which the original support was exposed and of that of the objective of the projector by which the printed record is to be shown so that a composite "aerial image" of the colour filter is formed within the optical system and is projected on to the support to be printed, and in guiding the supports by gates or the like at least one of which is curved, the curvatures of the guides being such that the angle between a line drawn from a given point on a support to the centre of curvature of the gate guiding that support and a line from the said point on the support to the point of intersection of the optical axis by the virtual image of the filter is, in the case of the original

- support, equal to the corresponding angle in the camera and, in the case of the support to be printed, equal to the corresponding angle in the projector. 25
2. In apparatus for printing a record or copy having colour values from an original record formed through a colour filter, one or each of these records being made on a lenticulated support, the combination with two gates or guides one for the original support and one for the support to be printed, either or both these guides being curved, of an optical system arranged between the guides and having a focal length independent of that of the objective of the camera in which the original support was exposed and of that of the objective of the projector by which the printed record is to be shown, each gate or guide being so arranged relatively to the optical system that the angle between a line drawn from a given point on the support to the centre of curvature of the gate and a line from the said point on the support to the intersection of the optical axis by the virtual image of the filter is, in the case of the original support, equal to the corresponding angle in the camera and, in the case of the support to be printed is equal to the corresponding angle in the projector. 30
3. The herein described method of printing a photographic record having colour values from another or original picture record made through colour filters. 35
4. The apparatus for printing a photographic record on one motion picture film from another substantially as described and shown in Figures 1 and 2 or Figure 3 or Figure 4 or Figure 5 or Figure 6 or Figure 7 of the accompanying drawings. 40
- Dated this 20th day of August, 1931.  
 KILBURN & STRODE,  
 Agents for the Applicants.

Fig. 1.

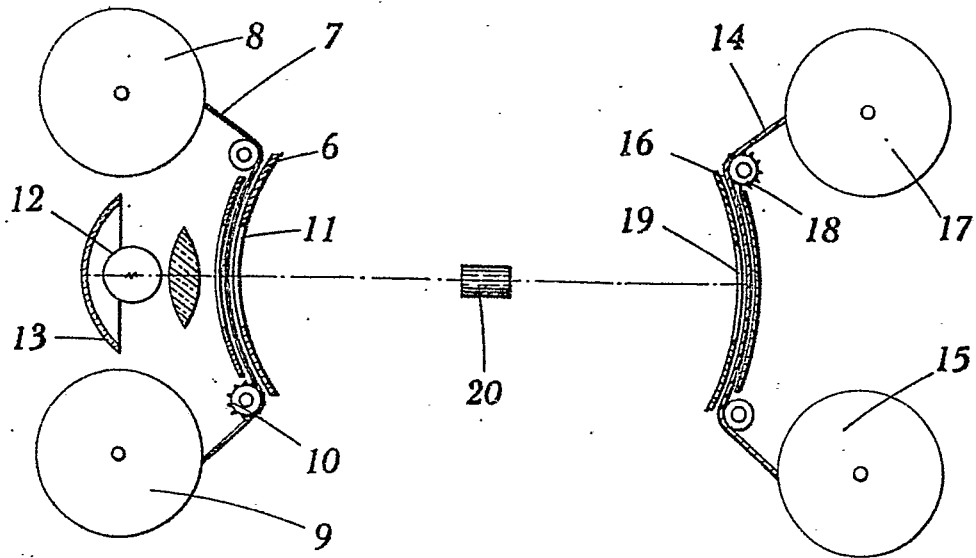


Fig. 2.

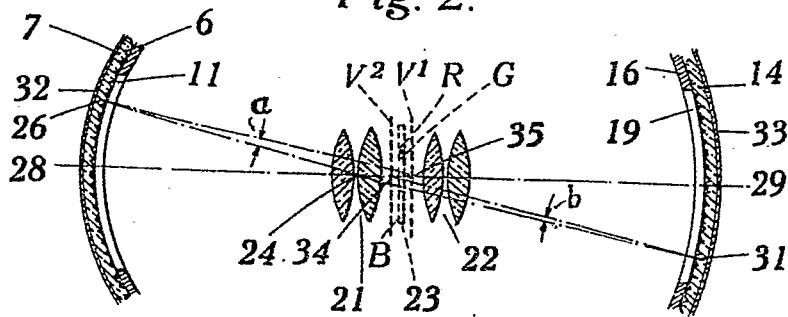
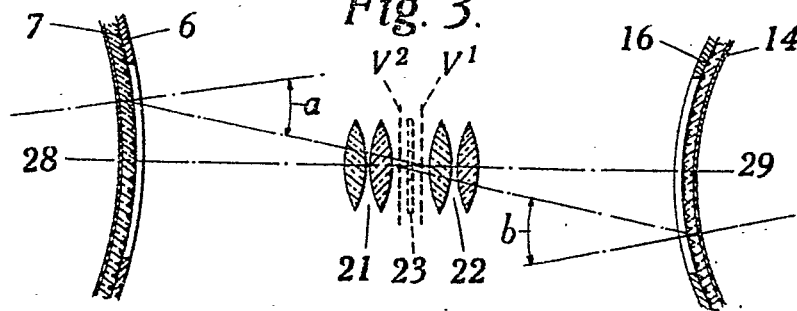


Fig. 3.



[This Drawing is a reproduction of the Original on a reduced scale.]

Fig. 4.

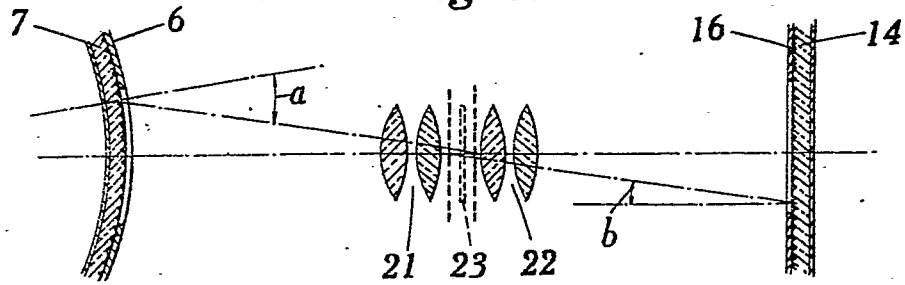


Fig. 5.

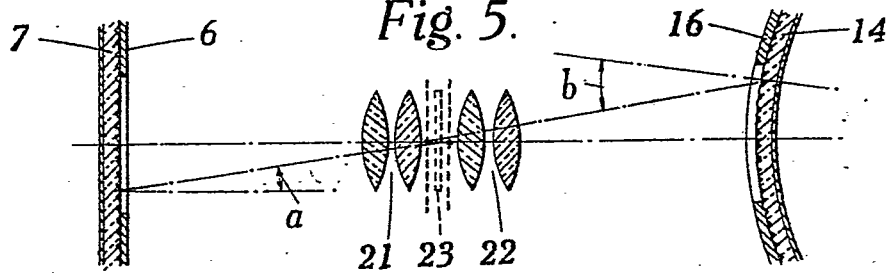


Fig. 6.

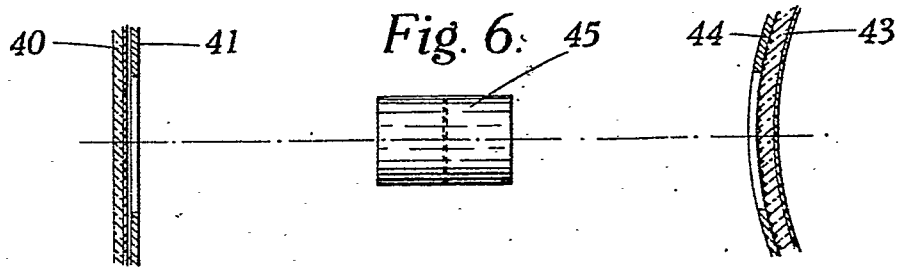


Fig. 7.

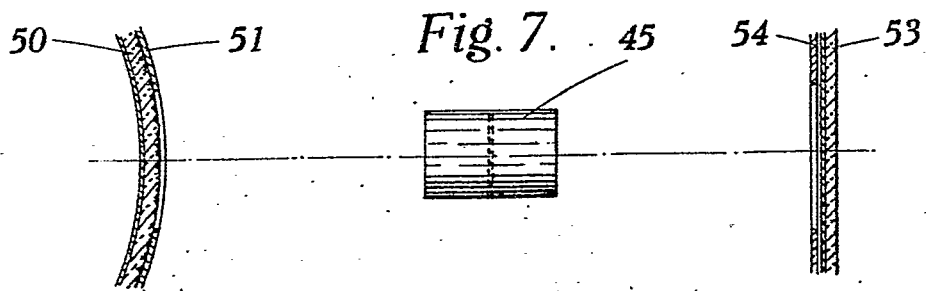


Fig. 8.

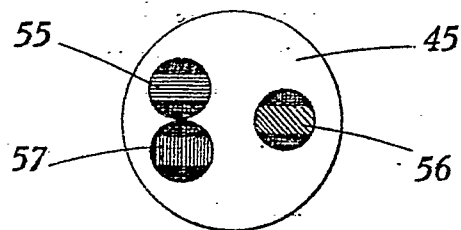


Fig. 1.

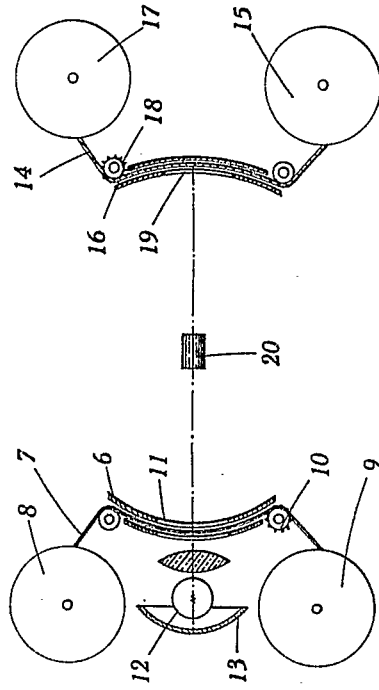


Fig. 2.

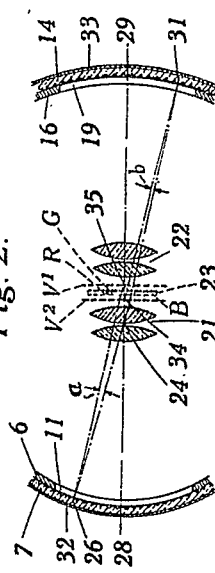


Fig. 3.

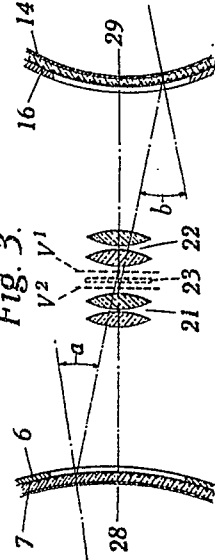


Fig. 4.

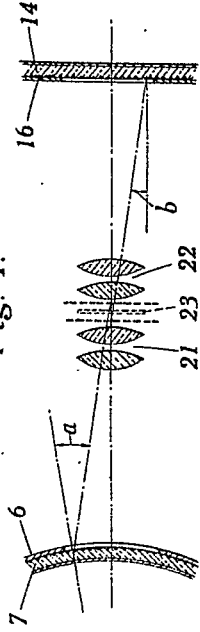


Fig. 5.

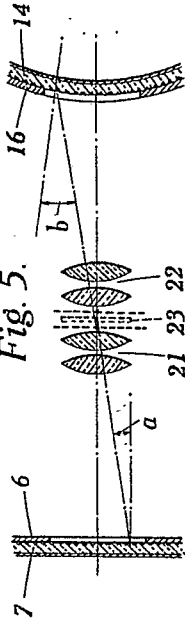


Fig. 6.

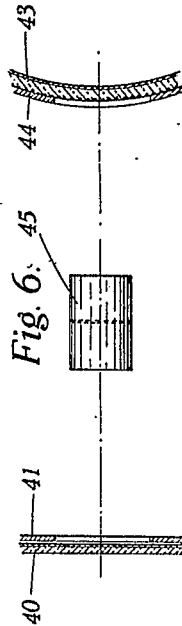


Fig. 7.

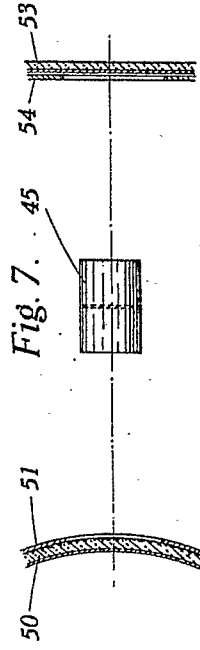
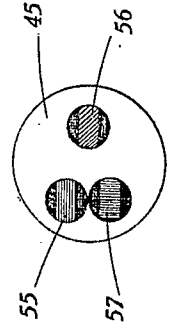


Fig. 8.



[This Drawing is a reproduction of the Original on a reduced scale.]